A New Tool for Industry

A device for measuring stress on critical bolts exemplifies spinoff aids to industrial efficiency and productivity

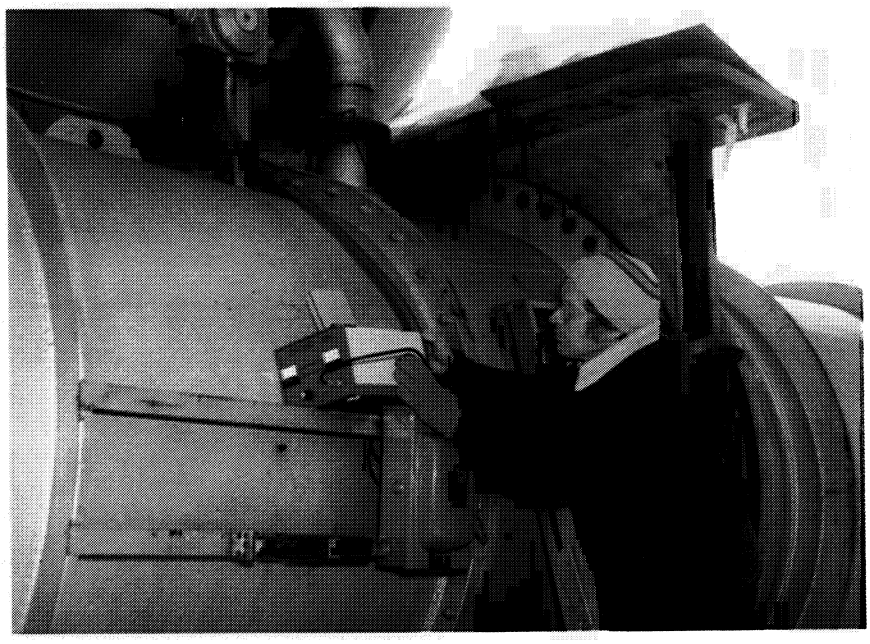
Bolt tightening seems a simple and routine matter. It can, however, be a very important process in cases where the bolt is subjected to severe stresses and strains—for example, in such structures as pressure vessels, bridges or power plants. In these and other instances, exact measurement of bolt stress is critical. Overtightened or undertightened bolts can fail and cause serious accidents or costly equipment breakdowns.

There are a number of methods for measuring bolt stress. Most widely used and least expensive is the torque wrench. But the torque wrench is inherently inaccurate because it does not take into account the variables in friction between nut, bolt and workpiece, which have an influence on bolt stress. At the other end of the spectrum, there are systems which accurately measure bolt stress but require complicated electronics and other equipment which make bolt tensioning an expensive procedure.

For measurement of bolt stress in wind tunnels—where bolted segments must withstand high pressures—Langley Research Center sought a system which would provide extremely precise stress information without the high costs associated with existing accurate systems. The result, after several years of research and development by Langley's Ultrasonic Laboratory, is the ultrasonic P^2L^2 bolt tension monitor, a new industrial tool which is lightweight, portable, extremely accurate because it is not subject to friction error, and cost-competitive with the least expensive of other types of accurate strain monitors.

P^2L^2 is an acronym for technical language—Pulse Phase Locked Loop—which describes to the initiated the essence of the system. In simpler terms, it is an ultrasound system which measures the stress that occurs when a bolt becomes elongated in the process of tightening. The instrument transmits sound waves to the bolt being fastened and receives a return signal indicating changes in bolt stress, changes somewhat analogous to the manner in which a violin string changes tone when it is tightened. Throughout the tightening process, the highly sensitive monitor measures the effective changes in resonance due to elongation of the bolt and changes in the velocity of sound due to strain. The results are

At the Colorado School of Mines Experimental Mine Facility, NASA and the Department of the Interior's Bureau of Mines are testing mine roof bolts with a NASA-developed ultrasonic bolt stress monitor. The instrument monitors the bolt tensioning process and provides increased safety by assuring proper preloading of roof bolts. It also has utility in industrial applications.

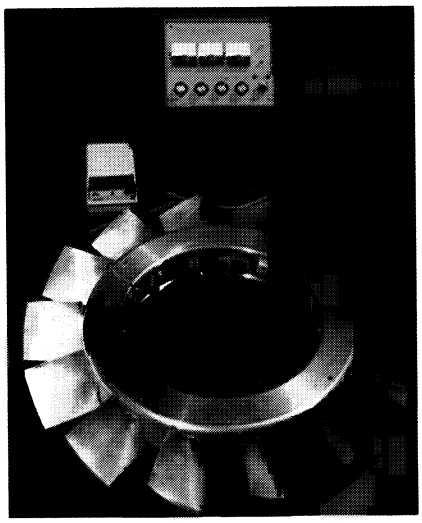


An example of the Langley ultrasonic monitor's utility is shown in this photo of a large valve assembly where a flange is being jacked into place. Measurement of the strain differences among the bolts provides information for exact alignment of the flange.

translated into a digital reading of the real stress on the bolt, a guide to proper fastening.

One version of the monitor is now entering industrial service and Langley has developed a new version for a special, potentially important application: checking bolt stress in the roofs of mine tunnels, where mammoth bolts several feet long extend far into solid rock. In a cooperative program with the Bureau of Mines, Langley is conducting tests to see if the device offers an improved way of assuring mine safety by determining whether a bolt is truly stressed. Langley and the Bureau of Mines are planning a further step: modifying the monitor to measure stress of the rock surrounding a mine tunnel. Rock stress varies from mine to mine and it may change over time due to such influences as shifting rock or mining techniques; detection of stress changes could serve as a hazard warning. If direct rock stress measurement proves feasible, it could provide broad benefit to mining, highway tunnel construction and related activities, such as earthquake prediction.

Langley's P^2L^2 bolt tension monitor has aroused considerable interest in industrial circles. NASA has patented the instrument and a number of companies have been granted licenses for its commercial manufacture; some are already producing it and others are conducting tests preparatory to production. The potential applications go well beyond bolt monitoring. The basic ultrasonic systems developed during the program can be adapted to such other uses as measuring stress changes in metals, investigating lubricants and hydraulic fluids for contaminants, or testing blood or other liquids for particulates, bubbles or clots.



In turbine engine construction, rotor fan blades must be fastened with precise tolerance between blade and housing, not only at installation but during engine operation—when the loads on the blades change due to high temperature and high rotational speed. Here the ultrasonic strain monitor, attached to a blade/rotor assembly, is measuring the preload on a fastener with a degree of accuracy not attainable by conventional torque systems, thereby assuring precise tolerance.